



MODEL ANSWER

WINTER- 18 EXAMINATION

Subject Title: Industrial Measurements

Subject Code:

22335

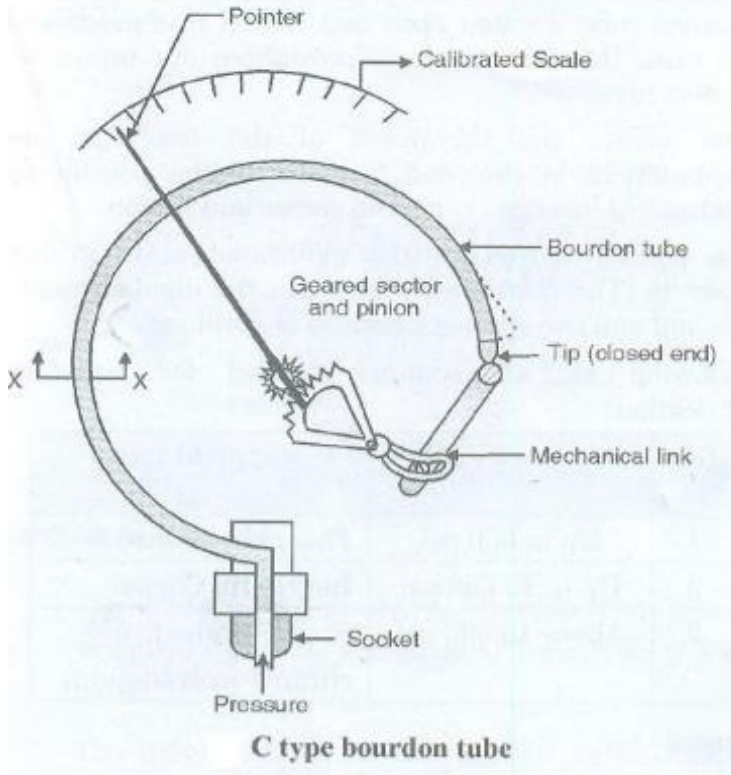
Important Instructions to examiners:

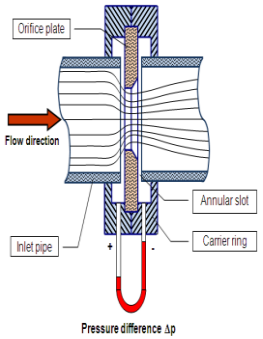
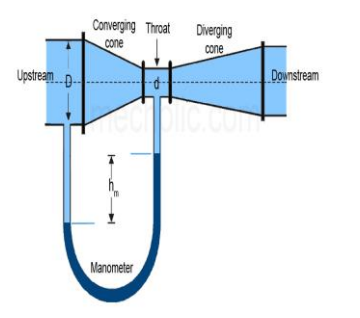
- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

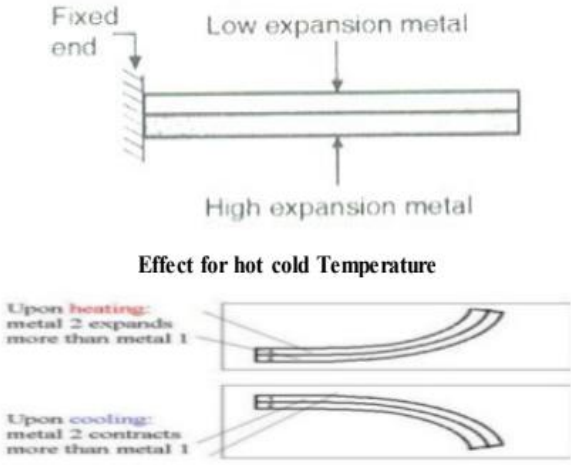
Q. No.	Sub Q.N.	Answer			Marking Scheme								
Q.1		Attempt any FIVE of the following :			10-Total Marks								
	(a)	Define Transducer. Give <u>two</u> examples.			2M								
	Ans:	Transducer : The device which convert one form of energy into another form is called Transducer Examples: Bellows, diaphragm, Bourdon tube Transducer, RTD, Strain gauge			1M ½ M each for example								
	(b)	Compare Active & Passive Transducers. (Two points)			2M								
	Ans:		<table><tr><th>Active Transducer</th><th>Passive transducer</th></tr><tr><td>1.The active transducer does not use any external power source for producing the output</td><td>The passive transducer requires the additional energy source for working.</td></tr><tr><td>2.Additional source is not required</td><td>2. Additional source is required</td></tr><tr><td>3. Solar Cell, Tachogenerator, Thermocouple, Photovoltaic cell, piezoelectric transducer</td><td>3. LVDT, Thermistor, RTD, Strain gauge, potentiometer, capacitive transducer</td></tr></table>	Active Transducer	Passive transducer	1.The active transducer does not use any external power source for producing the output	The passive transducer requires the additional energy source for working.	2.Additional source is not required	2. Additional source is required	3. Solar Cell, Tachogenerator, Thermocouple, Photovoltaic cell, piezoelectric transducer	3. LVDT, Thermistor, RTD, Strain gauge, potentiometer, capacitive transducer		1M Each Point
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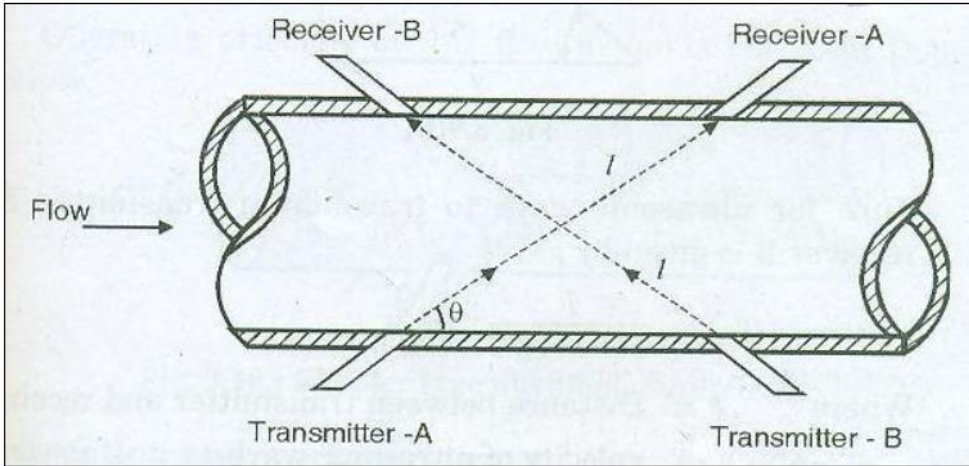


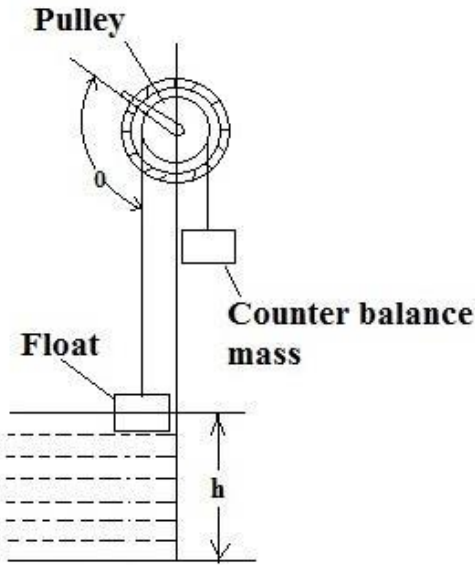
(c)	Define : (i) Absolute pressure (ii) Gauge pressure		2M
Ans:	(i) Absolute pressure: Absolute Pressure is the actual pressure including atmospheric pressure acting on a surface. It is abbreviated as psia (pounds per square inch absolute) (ii) Gauge pressure: The difference between the actual and atmospheric pressure is called gauge pressure. The pressure here is abbreviated as psig (pounds per square inch gauge)		1M 1M
(d)	State the formula for Reynold's number.		2M
Ans:	$Re = \frac{vd\rho}{\mu}$ v - velocity of flow in m/s; d - diameter of pipe in m; ρ -density of fluid in kg/m ³ μ - viscosity of fluid in Ns/m ²		2M
(e)	List the types of orifice plates.		2M
Ans:	There are four types of Orifice plates: 1. Concentric Plate 2. Eccentric Plate 3. Segmental Plate 4. Quadrant type		$\frac{1}{2}$ M $\frac{1}{2}$ M $\frac{1}{2}$ M $\frac{1}{2}$ M
(f)	List the indirect methods for Level Measurement.		2M
Ans:	Indirect Measurement: <ul style="list-style-type: none"> Hydrostatic Level Measurement Method Capacitive level measurement method Ultrasonic Type Level detection Radiation type level detector RADAR type level detector 		$\frac{1}{2}$ M each For any four
(g)	Define Temperature. List different temperature scales.		2M
Ans:	Temperature: the degree of Hotness and coldness of any substance is called temperature of that substance. List different temperature scales. 1) Degree celsius or centigrade(⁰ C) 2) Degree Fahrenheit (⁰ F)		1 M 1M

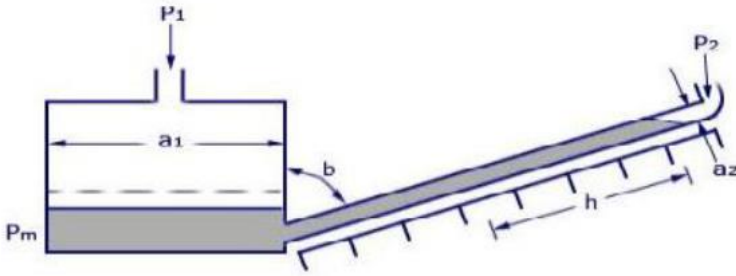
		3) Kelvin ($^{\circ}\text{K}$) 4) Degree Rankin ($^{\circ}\text{R}$)	
Q 2		Attempt any <u>THREE</u> of the following:	12-Total Marks
	(a)	Explain the working of 'C' type Bourdon tube with neat diagram.	4M
	Ans:	 <p style="text-align: center;">C type bourdon tube</p> <p>Working:</p> <ul style="list-style-type: none"> • C type bourdon tube is made up of an elliptically flattened tube bent in such a way as to produce the 'C' shape as shown in the figure. • One end (free end) of this tube is closed or sealed and the other end (fixed end) is opened for the pressure to enter. • The free end is connected to the pointer with the help of geared sector and pinion. Calibrated scale and pointer is provided to indicate the pressure. • The cross section view of 'C' type bourdon tube under normal condition is as shown in figure. • The pressure which is to be measured is applied to the bourdon tube through open end. • When this pressure enters the tube, the tube tends to straighten out proportional to applied pressure. • This causes the movement of the free end and the displacement of this end is given to the pointer through mechanical linkage i.e. geared sector and pinion. • The pointer moves on the calibrated scale in terms of pressure. The relationship between the displacement of the free end and the applied pressure is nonlinear. 	2M

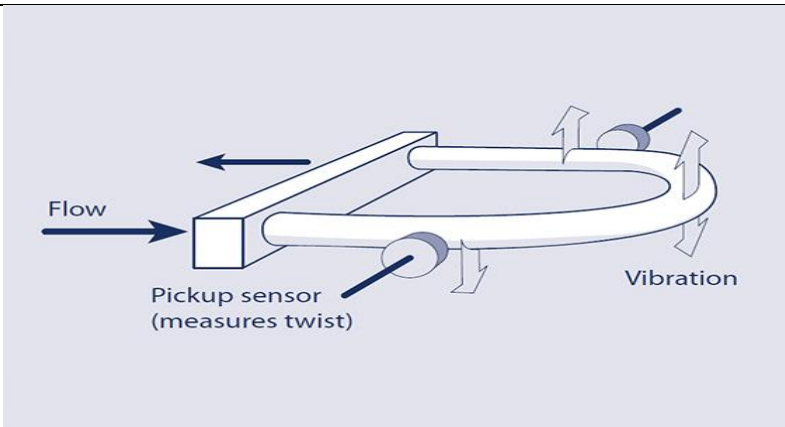
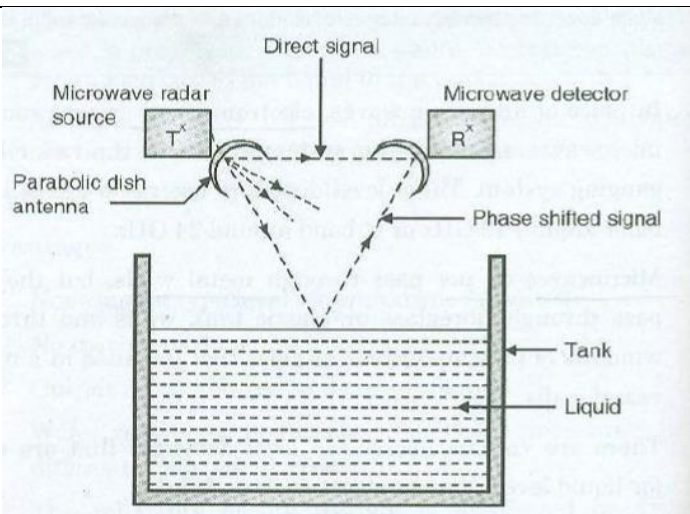
	(b)	Compare orifice plate and venturi tube with reference to working principle, construction, maintenance and cost.			4M
	Ans:	Parameters	Orifice plate	Venturi meter	
		Working principle	By reducing the cross sectional area of the flow passage suddenly, the pressure difference is developed and is proportional to flow rate of the fluid. Flow rate $Q \propto \sqrt{\Delta P}$	By reducing the cross sectional area of the flow passage gradually, the pressure difference is developed and is proportional to flow rate of the fluid. Flow rate $Q \propto \sqrt{\Delta P}$	1M
		Construction	 <p>OR</p> <p>Consists of flat circular plate made up of stainless steel with a hole drilled in it.</p>	 <p>OR</p> <p>It consists of inlet section called as converging cone, cylindrical throat and gradually diverging cone.</p>	1M
		Maintenance	Maintenance is high	Comparatively low	
		Cost	Comparatively low	Comparatively high	
					1M

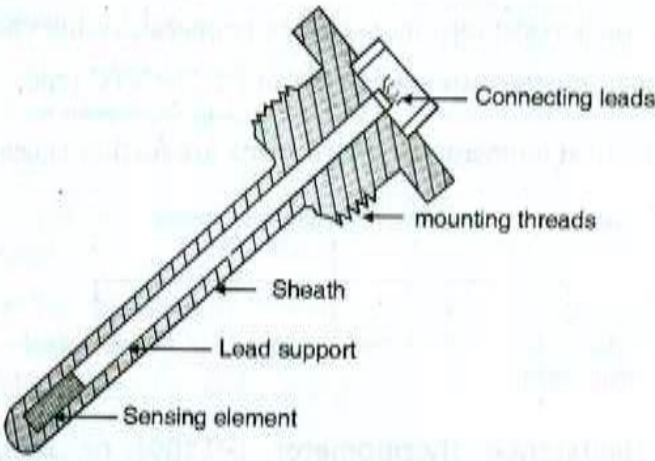
(c)	Differentiate between radiation type level measurement and capacitive type level measurement based on type of measurement, application, cost & accuracy.				4M
Ans:	Parameters	Radiation type level measurement	Capacitive type level measurement		
	Measurement	It is Non-contact type Technique of measurement. It is based on absorption level of radiation.	It is contact technique. It works on the principle of change in capacitance due to change in dielectric constant or overlapping area due to change in level of tank		
	Application,	The Radiation type level measurement is suitable for level measurement of hot liquid metal or solid material.	The capacitive type level measurement is suitable for level measurement of slurries.		
	Cost	It is relatively expensive.	It is relatively economical		
	Accuracy	It is accurate than capacitive type	It is comparatively less accurate.		
(d)	Explain the working principle of Bimetallic thermometer with neat diagram.				4M
Ans:	 <p>Working Principle: Bimetallic strip is made up of two different metals soldered together. As the temperature is applied to the strip, there is deflection of the free end of the strip. The length of metal will change according to the individual expansion rate.</p> <p>It works on two different principles</p> <ol style="list-style-type: none"> 1. All metals expand or contract with change in temperature. 2. The temperature coefficient of expansion is not same for all metals; therefore their rate of expansion or contraction is not same. <p>The difference in thermal expansion rate produces deflections proportional to</p>				2M
					2M

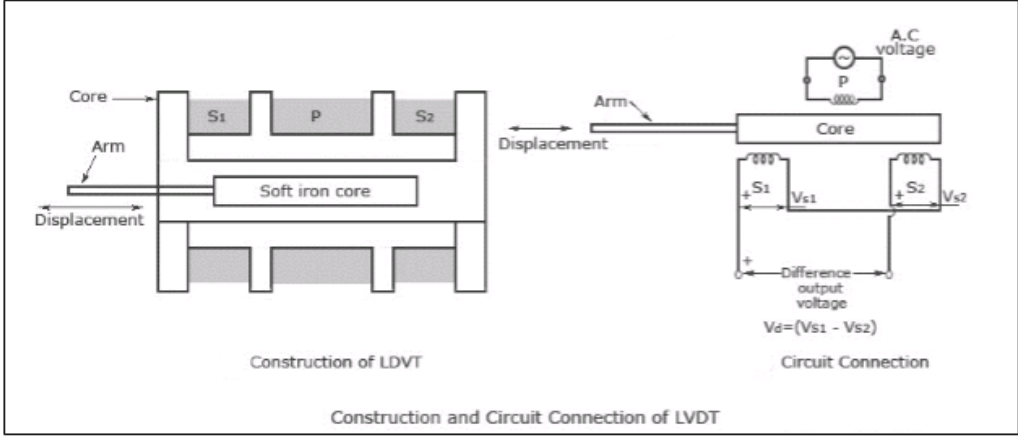
		the change in temperature.	
Q. 3		Attempt any <u>THREE</u> of the following:	12-Total Marks
	(a)	Explain the selection criteria for Transducers. (any four points)	4M
	Ans:	<ol style="list-style-type: none"> 1. Operating range :Range is specified user or manufacturer 2. Operating principle : Depend on principle measurement 3. Sensitivity: it must sensitive to small variation in input. 4. Accuracy: It must be accurate to given tolerance 5. Frequency response and resonant frequency: It should operate constant in given band width. 6. Errors : Minimum 7. Environmental compatibility: It should compatible to given environment 8. Usage and ruggedness. 9. Electrical aspect: should consider Power rating, operating voltage, S/N ratio. 10. Stability and Reliability: To handling and operating it should be highly stable and reliable. 11. Loading effect: Input impedance should be high and output impedance should be low to handle loading problems. 12. Static characteristics: Includes low-nonlinearity, low hysteresis loss. 13. Cost and range 	Any 4 points with explanation- 1M for each point
	(b)	Describe the working of ultrasonic flow meter with neat diagram.	4M
	Ans:	 <p>Explanation:-</p> <ul style="list-style-type: none"> • The operating principle of this flow meter is based on the apparent change in the velocity of propagation of ultrasonic wave pulses in a fluid with a change in velocity of fluid flow. • This flow meter consists of two transmitters and two receivers. These are separated by distance. • Transmitter A transmits the waves pulsed of short duration in the direction of receiver A, this favor the wave as it is in direction of low. • Transmitter B transmits the wave pulsed of short duration in the direction of receiver B, this do not favor the wave as it is opposite to the direction of low. • The velocity of ultrasonic waves is increased or decreased by the fluid velocity depending upon the direction of fluid. 	2M

	<ul style="list-style-type: none"> The detector measures the transit time from upstream to downstream and vice versa. 	
(c)	Explain with the help of neat sketch float type level measurement.	4M
Ans:	 <p>Liquid level measurements using float</p> <p>Explanation:</p> <ol style="list-style-type: none"> A float is hollow object. the weight of the float and counter balance mass are chosen such that the float remains half-immersed in the liquid. The float is connected to a pulley arrangement which is connected to a pointer and scale which is calibrated in terms of level. (Note: Float which is connected to the potentiometer wiper can be considered) 	<p>2M</p> <p>2M</p>
(d)	Describe the procedure to troubleshoot the Faults in a thermistor circuit. (any two faults)	4M
Ans:	<p>Procedure to troubleshoot the Faults in a thermistor circuit:</p> <ol style="list-style-type: none"> The thermistor is a temperature-sensitive resistor; therefore an ohmmeter can be used to test the thermistor if it's isolated or removed from its circuit and power source. As heat is added to the thermistor, its resistance should drop (for NTC). If the temperature is in the middle of the thermistor's operating range, the amount of resistance change should be much larger than an RTD. e.g., the resistance of one standard type of thermistor material would have 19.59 k Ω at 0°C and 407 Ω at 100 °C. If the resistance of the thermistor does not change, or if the value is always infinity ∞, the thermistor is defective and must be changed. The infinity reading indicates the thermistor has an open, but one must use a very high resistance scale on the meter. In practical setup of Thermistor (NTC or PTC) circuit, troubleshoot can 	<p>2M for each fault troubleshooting procedure</p>

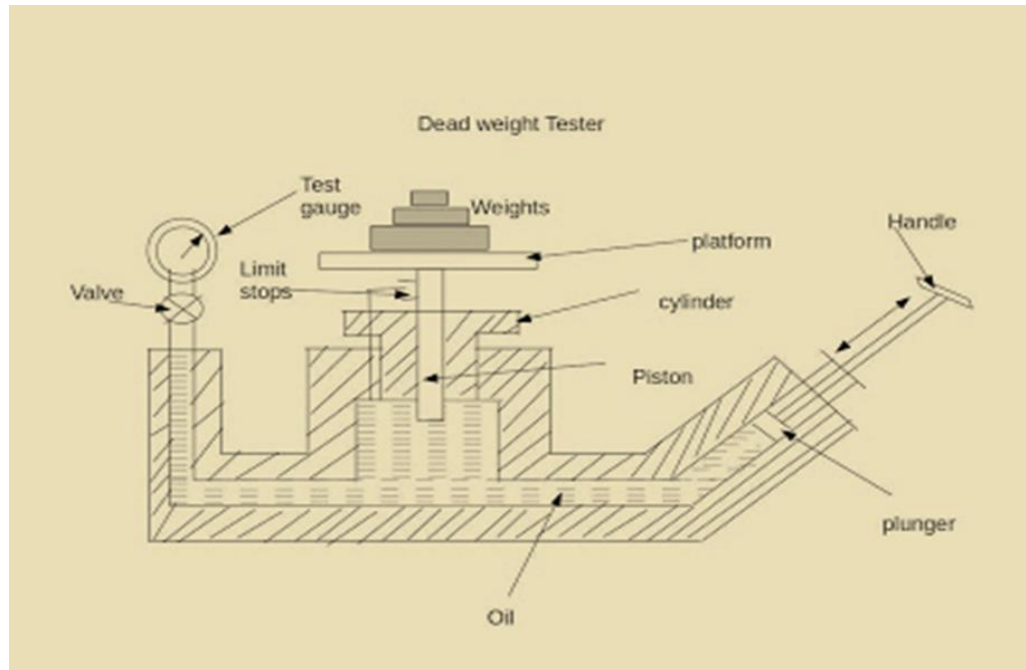
		be done by using equipment like Heater, dry blower, or any type of heating device. Check value for the resistance with respect to the change in the temperature. If the resistance value is infinity, Thermistor is faulty	
Q. 4		Attempt any <u>THREE</u> of the following :	12-Total Marks
	(a)	Give two examples of : (i) Active Transducer (ii) Resistive Transducer (iii) Inductive Transducer (iv) Digital Transducer	4M
	Ans:	<p>(i) Active Transducer: Tachogenerators, Photovoltaic cell, Thermocouple, Piezoelectric transducer.</p> <p>(ii) Resistive Transducer: Thermistor, RTD, strain-gauge, potentiometer.</p> <p>(iii) Inductive Transducer: LVDT, RVDT.</p> <p>(iv) Digital Transducer: Optical encoder, Digital temperature sensor, Digital accelerometer</p>	<p>$\frac{1}{2}$ M</p> <p>$\frac{1}{2}$ M</p> <p>$\frac{1}{2}$ M</p> <p>$\frac{1}{2}$ M</p>
	(b)	Sketch constructional diagram of Inclined Manometer. State its advantages and disadvantages.	4M
	Ans:	 <p style="text-align: center;">Inclined Tube manometer</p> <p>Advantages:</p> <ol style="list-style-type: none"> 1) High sensitivity and accuracy 2) Used to measure small pressure difference <p>Disadvantages:</p> <ol style="list-style-type: none"> 1) Lack of Portability 2) No over range protection 	<p>2M</p> <p>1M</p> <p>1M</p>

(c)	Explain the working of Corioli's flow meter with neat diagram.	4M
Ans:	<div data-bbox="321 239 1101 663" data-label="Image">  </div> <p>Working:</p> <ol style="list-style-type: none"> 1. Coriolis flow meter consists of a vibrating tube in which a fluid flow causes changes in frequency, phase shift or amplitude. The “swinging” is generated by vibrating the tube in which the fluid flows. 2. The sensor signal is fed into the integrally mounted pc-board. 3. The resulting output signal is strictly proportional to the real mass flow rate, whereas thermal mass flow meters are dependent of the physical properties of the fluid. 4. The amount of twist is proportional to the mass flow rate of fluid passing through the tube. Coriolis mass flow measurement is fast and very accurate. 	<p>2M</p> <p>2M</p>
(d)	Draw the diagram of Radar level measurement. Write one advantage & disadvantage of it.	4M
Ans:	<div data-bbox="370 1291 1055 1801" data-label="Image">  </div> <p>Advantages:</p> <ol style="list-style-type: none"> 1) This is non contact method 2) High accuracy for measurements in storage tanks and process vessels 	<p>2M</p> <p>1M</p>

	Disadvantages: 1) Expensive technology. 2) Reading is affected by change in density of liquid	1M
(e)	With the help of neat labelled diagram describe the operation of RTD.	4M
Ans:	 <p>Explanation:</p> <ol style="list-style-type: none"> 1. It is made up of a metallic resistance element (usually platinum) 2. The resistance of RTD increases with increase in the temperature. 3. The relation between the resistance element and temperature is as given below: $R_t = R_0(1 + \alpha t)$ α - temperature coefficient of the material R_0- temperature at t_0 4. The variation of the resistance of RTD is normally measured by Wheatstone bridge by keeping RTD as one arm of Wheatstone bridge. Two or three or four wire configuration can be used. 	2M

Q.5		Attempt any <u>TWO</u> of the following :	Total Marks 12
	(a)	Explain construction, working principle of LVDT with circuit diagram & show three positions.	6M
	Ans:	<div style="text-align: center;">  <p>Construction of LVDT</p> <p>Circuit Connection</p> <p>Construction and Circuit Connection of LVDT</p> </div> <p>(Any one diagram)</p> <p>Working principle :</p> <ul style="list-style-type: none"> Linear variable differential transformer (LVDT) consists of one primary winding & two secondary winding and a ferromagnetic core in between the windings. When the core is displaced, two unequal voltages are introduced in secondary winding. To obtain single voltage at output, secondary windings are connected in series opposition. Hence output will be the differential output which is the difference between the two secondary voltages. Therefore $V_0 = V_1 - V_2$. Hence it is differential transformer. <p>Three core position :</p> <p>When core is in neutral or zero position, voltages induced in secondary winding are equal; so net output is zero.</p> <p>When core is moved right from zero position then output is in phase and positive.</p> <p>When core is moved towards left from zero position then output is 180 degree out of phase and negative.</p>	<p>2 M</p> <p>2M</p> <p>2M</p>
	(b)	Classify pressure measurement techniques. Describe how calibration of pressure gauge is done by using dead weight tester.	6M
	Ans:	<p>Methods of pressure measurement:</p> <p>1. Manometer method</p>	2M

2. Elastic Pressure Transducer like Bourdon tube, bellows and diaphragm
3. Electrical pressure measurement with bourdon tube-LVDT, diaphragm-strain gauge, bourdon tube-potentiometer



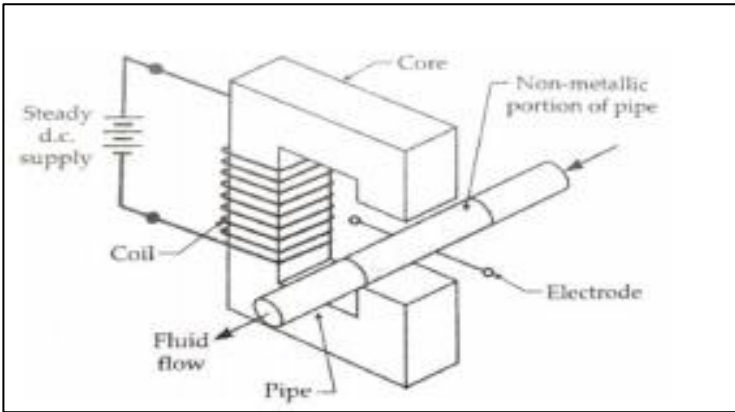
2M

- The dead weight tester apparatus consists of a chamber which is filled with oil and a piston – cylinder. The top portion of the piston is attached with a platform to carry weights. A plunger with a handle has been provided to vary the pressure of oil in the chamber. The pressure gauge to be tested is fitted at an appropriate plate.

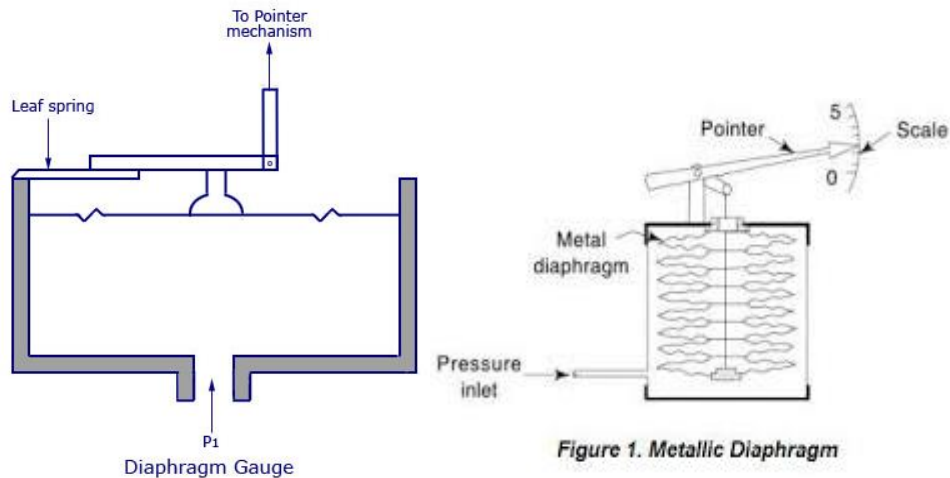
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Operation:

- The dead weight tester is used to calibrate pressure gauges. Calibration of pressure gauge means introducing an accurately known sample of pressure to the gauge under test and then observing the response of the gauge.
- A known weight is placed on the platform.
- Now by operating the plunger, fluid pressure is applied to the other side of the piston until enough force is developed to lift the piston-weight combination.
- When this happens, the piston weight combination floats freely within the cylinder between limit stops. The pointer of the gauge indicates the pressure.

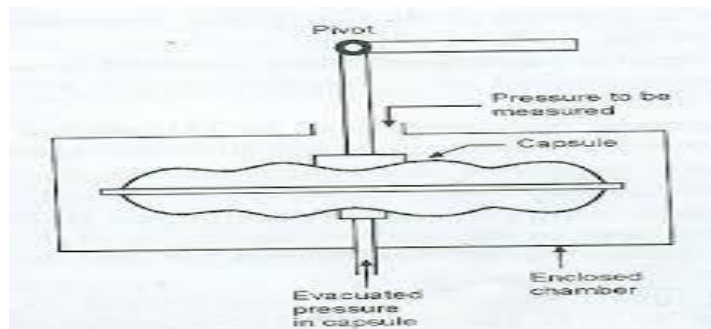
(c)	Describe the working principle along with construction of electromagnetic type flow meter. State its two advantages & application.	6M
Ans:	<div data-bbox="500 268 1230 676" data-label="Image">  </div> <ul style="list-style-type: none"> • Electromagnetic flow meters are based on Faraday's Law of Electromagnetic Induction. According to this principle, when a conductive medium passes through a magnetic field B, a voltage E is generated which is proportional to the velocity v of the medium, the density of the magnetic field and the length of the conductor. • In an Electromagnetic flow meter, a current is applied to the coils mounted within or outside the meter body to generate a magnetic field. • The liquid flowing through the pipe acts as the conductor and this induces a voltage which is proportional to the average flow velocity. • This voltage is detected by sensing electrodes mounted in the Electromagnetic flow meter body and sent to a transmitter which calculates the volumetric flow rate based on the pipe dimensions. • <p style="text-align: center;">The induced voltage $E = B L V$</p> <p style="text-align: center;">Where B=flux density wb/m² L=length of Conductor i.e diameter of pipe in meter v= velocity of Conductor i.e flow velocity m/sec</p> <p>Advantages :</p> <ul style="list-style-type: none"> • Can be used for slurries and greasy material • Can handle corrosive fluid & has low pressure drop • Totally obstruction less • Can handle low flows • Used as a bidirectional meter • Measurement is unaffected by viscosity, density, temperature and pressure <p>Applications</p> <ul style="list-style-type: none"> • Measurement of flow of slurries 	<div data-bbox="1373 268 1422 302" data-label="Text">2M</div> <div data-bbox="1373 928 1422 961" data-label="Text">2M</div> <div data-bbox="1373 1659 1422 1692" data-label="Text">1M</div>

		<ul style="list-style-type: none"> • Measurement of flow of corrosive acids • Measurement of flow of detergents 	1M
Q.6		Attempt any <u>TWO</u> of the following:	Total Marks 12
(a)		<p>Explain with neat sketches the working of the following elastic pressure transducers :</p> <ol style="list-style-type: none"> Bellows Diaphragm Capsule 	6M
Ans:		<div style="border: 1px solid black; padding: 10px;"> <h3 style="text-align: center;">Bellows</h3> <p>➤ A bellows gauge contains an elastic element that is a convoluted unit that expands and contracts axially with change in pressure.</p> <p>➤ The pressure to be measured can be applied to the outside or inside of the bellows however, in practice, most bellows measuring devices have the pressure applied to the outside of the bellows.</p> </div> <p>Diaphragm Slack Diaphragm Or Metallic diaphragm</p>	(2 mark)
			2M



When pressure is applied, the displacement of diaphragm takes place and hence it will either expand or contract and hence the pointer attached to it will move over calibrated scale.

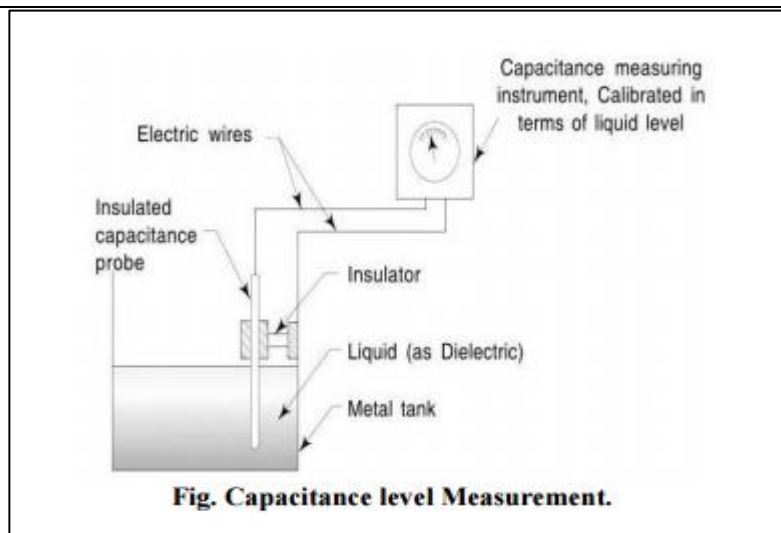
Capsule :



Capsule gauges are designed for measuring low/very low pressures and vacuum. The capsule consists of two diaphragms joined and sealed around their circumference.

- (b) **Draw and explain the diagram of capacitance level measurement with reference to**
 (i) Calibration procedure
 (ii) merits

Ans:





The principle of operation of capacitance level measurement is based on the equation of a parallel plate capacitor given by:

$$C = K \frac{A}{D}$$

where, C = Capacitance, in farad

K = Dielectric constant

A = Area of plate, in m^2

D = Distance between two plates, in m

2M

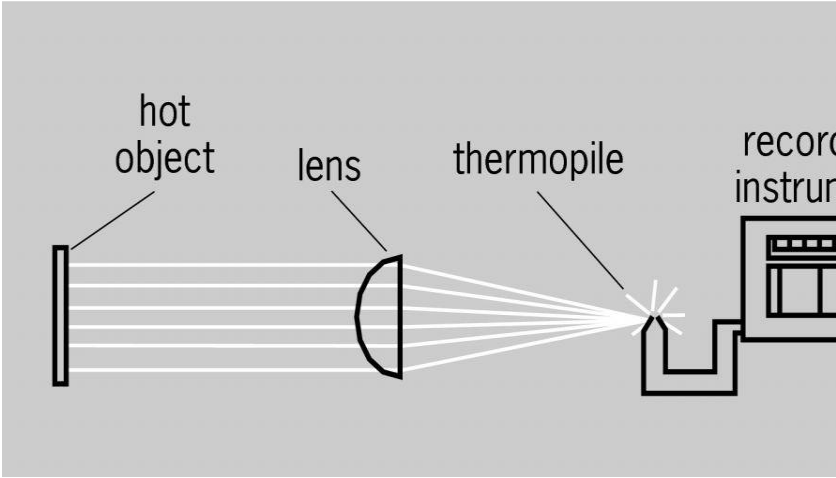
(i) Calibration procedure

- It consist of an insulated capacitance probe (which is metal electrode) firmly fixed near and parallel to the metal wall of the tank.
- If liquid in the tank is non-conductive, the capacitance probe and the tank wall form the plates of a parallel plate capacitor and liquid acts as the dielectric.
- If liquid is conductive, the capacitance probe and liquid form the plate of the capacitor and the insulation of the probe act as the dielectric.
- A capacitance measuring device is connected with the probe and the tank wall, which is calibrated in terms of the level of liquid in the tank.
- When the level of liquid in the tank increases, the capacitance increases and vice versa.
- This increase and decrees in the capacitance is measure and is displayed on the indicated calibrated in terms of liquid level.
- If error exist in the measurement range either in min. level or max. level.
- Adjust zero for min level error or adjust span for max.level error.
- Also perform cleaning of capacitance probe.

2M

ii)Merits

- a. Inexpensive
- b. simple to operate
- c. high electrical efficiency

	(c) Describe working of radiation pyrometer with neat diagram. State its two applications and suitable temperature range.	6M
	<p>Ans:</p> <div data-bbox="315 273 1146 747" data-label="Diagram">  </div> <ul style="list-style-type: none"> • The operation is based upon the measurement of radiant energy emitted by hot body or principle of electromagnetic radiation. • It consists of lens, detector or receiving element such as RTD or thermocouple or thermopile and temperature indicator or controller attached to the receiving element. • When total energy radiated by the hot body whose temperature is to be measured enters the pyrometer, it is focused by the lens to the detector. • Detector is the thermopile whose measuring junctions are attached to a blackened disk • Disk absorbs energy when pyrometer is focused on hot body and its temperature rises. • The difference in temperature between the measuring junction attached to disk and the reference junction attached to outer case generates voltage directly proportional to the temperature of disk and indicated by recording instrument. <p>Applications:</p> <ul style="list-style-type: none"> • Used for temperature above practical operating range of thermocouples • Used for moving targets • Used for measurement of average temperatures of large surface area <p>Temperature Range:</p> <ul style="list-style-type: none"> • Above 1400 degree centigrade 	<p>2M</p> <p>2M</p> <p>1M</p> <p>1M</p>